Wideband Air-to-Ground Interference
Analysis of Nextel Communications

Michael Youngil Ha
Principal Technology Strategist
Nextel Communications
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Executive Summary

The proposed Wideband Air-to-Ground (WATG) service represents a radically changed use from today's narrowband Air-to-Ground operations. WATG will require more power, more transmitters, more bandwidth, and more on-air time than narrowband ATG does today. While WATG proponents have exhaustively debated whether multiple WATG providers can be licensed within the ATG band without interfering with each other, the impact on adjacent 800 MHz and 900 MHz public safety, critical infrastructure, Specialized Mobile Radio (SMR), and cellular licensees from the unacceptable interference that WATG service will produce is not adequately addressed.

Adjacent-band licensees have good reason to worry. The 800 MHz band suffers from interference problems that the Commission has spent more than two-and-a-half years working to resolve. The complex, $4.86 billion solution that the Commission adopted to resolve 800 MHz public safety interference required extensive analysis and significant cooperation from both the private sector and public safety licensees. With its new operational characteristics, however, WATG service could interfere with the mission-critical public safety communications systems the Commission has decided must be relocated to the lower 800 MHz channels to protect them from unacceptable interference. WATG service would be adjacent to those channels. It could also interfere with incumbent 900 MHz systems. Accordingly, Nextel Communications, Inc., the Association of Public-Safety Communications Officials, the Association of American Railroads, and the Cellular Telecommunications and Internet Association have each asked the Commission to impose the safeguards necessary to assure that WATG is a good spectrum neighbor.

The record in this proceeding provides little detail concerning how WATG systems would operate and even less information concerning what interference protection measures WATG would implement. With so little information available, the multiple interference threats that WATG poses are difficult to analyze definitively. Based on the best information available, however, this technical paper evaluates the potential for adjacent band interference and concludes that WATG will cause harmful interference to wireless communications in the spectrum adjacent to the ATG allocation. This paper also finds that WATG will experience interference from 800 MHz incumbent cellular service that, unless resolved, will significantly diminish the utility of WATG service to consumers.

Accordingly, before the Commission authorizes a new WATG service in the midst of a complex and interference-prone band, WATG proponents must provide, potentially affected licensees must have the opportunity to assess, and the Commission must review detailed proposals to mitigate interference to both 800 MHz and 900 MHz adjacent-band licensees.

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Introduction

This technical paper evaluates the potential for adjacent band interference from a new wideband Air-to-Ground Service (WATG) currently under consideration in WT Docket 03-103. The analysis finds that WATG will cause harmful interference to wireless communications services licensees located in the highly congested spectrum adjacent to the Air-to-Ground allocation in the 849-851 MHz and 894-896 MHz bands. These licensees include public safety, Specialized Mobile Radio (SMR), and cellular operations. This analysis also finds that Cellular A & B operations will cause harmful interference into WATG that, unless resolved, will significantly diminish the maximum broadband throughput that a WATG service could provide to consumers. Accordingly, this paper analyzes three interference scenarios and concludes that significant technical restrictions and interference-mitigation techniques are necessary to permit WATG deployment in the current 800 MHz ATG channel allocation without causing unacceptable interference to adjacent 800 MHz and 900 MHz wireless communications services.[1]

Discussion

1. Band Plan Overview and Interference Risk Factors

1.1. Current Air-to-Ground Service

As noted above, the current ATG service uses spectrum in the 849-851 MHz (ground-to-air) and 894-896 MHz bands (air-to-ground). Verizon Airfone is the only ATG licensee operating today with a network of approximately 200 towers dispersed throughout the United States supporting ATG service availability to approximately 1700 aircraft. Approximately 3900 calls are made per day (about 2.3 per aircraft) across the entire territory of the United States – evidence of the extremely low user demand for the current ATG service.[2] Existing ATG technology provides primarily voice-only service using 6 kHz narrowband channels within the 849-851 MHz/894-896 MHz ATG allocation. Under this technology, ATG transmitters are active only when users are making calls –

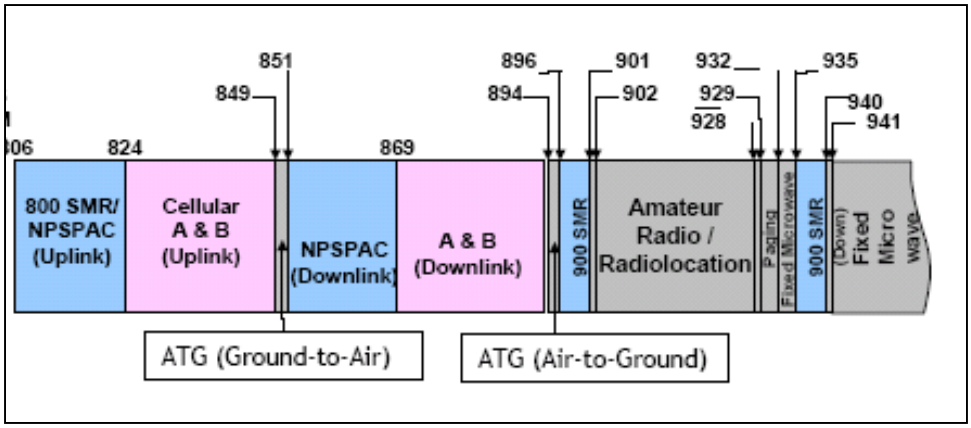
[1] WATG will also create interference into the Cellular A & B Uplinks and Cellular A & B downlinks. Although this paper does not evaluate those scenarios, they provide further evidence of the necessity of developing a comprehensive and complete record on the inter-band consequences of authorizing WATG in the current 800 MHz narrowband ATG allocation. In addition, as discussed *infra*, WATG will likely experience harmful interference from Cellular A & B operations.

[2] *See AirCell Oct. 14, 2004 Ex Parte Presentation,* WT Docket No. 03-103 App. 1 at 9 (*citing* Joe Sharkey, *New York Times,* Almost Here: Cell Phones at 37,000 Feet, (Oct. 10, 2004)).

an operating characteristic which significantly minimizes the probability of interference to adjacent channel communications services.

1.2. Adjacent Band Services

The bands adjacent to the current ATG allocation are heavily licensed to and used by wireless communications services. As shown in the diagram below, the lower ATG band adjoins: the 800 MHz General Category channels that are currently licensed to a variety of mobile communications services, including public safety communications systems, private wireless systems used by critical infrastructure industries such as electric, water, sewer and gas utilities, traditional high-site SMR operators, and low-site, cellular-type SMR operators, such as Nextel and Southern LINC. It is also adjacent to the Cellular A & B Block uplink channels. The upper WATG band adjoins 900 MHz SMR and the Cellular A & B Block downlink channels.



1.2.1. Lower ATG Band

As discussed in more detail below, the Federal Communications Commission (the "Commission") recently released a Report and Order (the "800 MHz Report and Order") in Docket No. WT 02-55 reconfiguring the 806-824/851-869 MHz portion of the 800 MHz band. The Commission found, after a two-and-a-half year comprehensive analysis, that band reconfiguration was the only practical way to eliminate unacceptable interference to public safety systems as a by-product of the Commission-authorized operations of spectrally adjacent and/or interleaved low-site commercial mobile radio systems (CMRS). Accordingly, the Commission adopted rules, procedures, and processes to create a contiguous channel block for public safety and other compatible high-site systems and a separate contiguous channel block for low-site, cellular-type operators, along with the technical requirements necessary to eliminate CMRS – public safety interference.

Because the *800 MHz Report & Order* would modify Nextel's licenses pursuant to Section 316 of the Commission's rules, the 800 MHz reconfiguration process will not be implemented unless Nextel agrees to accept these license modifications and takes a number of other steps – including establishing a $2.5 billion letter of credit – directed toward assuring that all incumbent licensees (including Nextel) experience minimal disruption while being relocated to comparable spectrum in accordance with the new

band plan.[3] Through a number of *ex parte* filings, Nextel has asked the Commission to clarify certain aspects of the *800 MHz Report and Order* to assure that band reconfiguration can be completed within the Commission's three-year timetable with minimal disruption to all incumbents, and the Commission is seeking public comment on these and other clarification requests.[4]

Nextel has indicated that, with these clarifications, it desires to accept the license modifications and the reconfiguration responsibilities set forth in the *800 MHz Report and Order*.[5] Accordingly, this paper assumes that the 800 MHz band will be reconfigured during the next three years in a manner that will retune all public safety communications systems currently licensed in the 821-824/866-869 MHz channel block, known as the National Public Safety Plan Advisory Committee (NPSPAC) channels, to the 806-809/851-854 channel block. Thus, the WATG analysis herein assumes that, within three years, the 806-809/851-854 channel block will transition to and become the NPSPAC channel block allocated for and licensed exclusively to public safety communications networks. WATG would be directly adjacent to the new NPSPAC channel block.

Under the *800 MHz Report and Order*, 800 MHz reconfiguration will be implemented in two phases on a region-by-region basis.[6] In Phase I of the 800 MHz reconfiguration,

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[3] *See Improving Public Safety Communications in the 800 MHz Band*, Report and Order, Fifth Report and Order, Fourth Memorandum Opinion and Order, and Order, WT Docket 02-55, 19 FCC Rcd 14969 (2004) (*800 MHz Report and Order*).

[4] *See Commission Seeks Comment on Ex Parte Presentations and Extends Certain Deadlines Regarding the 800 MHz Public Safety Interference Proceeding WT Dkt No. 02-55*, Public Notice, FCC 04-253 (rel. Oct. 22, 2004), *available at* <http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-04-253A1.doc>.

[5] Letter from Regina M. Keeney, Counsel to Nextel Communications, to Marlene Dortch, FCC Secretary, WT Docket 02-55, Attach. 1 at 2 (Sept. 21, 2004) (stating that clarifying the *800 MHz Report and Order* as requested by Nextel would promote an efficient band reconfiguration process that remedies the interference problem without unreasonably disrupting incumbent networks).

[6] Reconfiguration of the band will proceed on a region-by-region basis for each of the nation's 55 NPSPAC regions. Under the *800 MHz Report and Order*, the Transition Administrator is to provide the Commission with a schedule detailing when band reconfiguration shall commence for each NPSPAC Region based on various factors. The schedule must provide retuning of Channels 1-120 in twenty NPSPAC Regions within eighteen months. In addition, all systems must have commenced reconfiguration within thirty months of the release of a Public Notice announcing the start date of reconfiguration in the first NPSPAC region. The Transition Administrator is to adopt a schedule to ensure completion of the region-by-region band reconfiguration in no more than thirty-six months following the release of a Public Notice announcing the start date of reconfiguration in the first NPSPAC region. *See 800 MHz Report and Order*, 19 FCC Rcd at ¶ 201.

Nextel will relocate all 806-809/851-854 incumbents by retuning them to channels Nextel will surrender in the 809-817/854-862 channels block.[7] Nextel will maintain its operations and service to customers by taking each incumbent's place in the new NPSPAC channel block. Thus, at the end of Phase I, Nextel will be the sole licensee on these channels.

Then, in Phase II, current NPSPAC licensees will move into the new 806-809/851-854 channels on a system-by-system basis and Nextel will transition to their vacated original channels, such that at the end of Phase II the existing NPSPAC licensing structure is replicated at 806-809/851-854 MHz. This transition plan is at the heart of the Commission's solution to the CMRS/public safety interference problem at 800 MHz. The Commission has established stringent, expedited interference-abatement processes and standards to assure that interference to mission critical public safety communications is mitigated as quickly as possible both during the transition and once Phase II is completed.[8]

During Phase II, Nextel and public safety NPSPAC licensees will temporarily share the new NPSPAC channels as individual licensees retune their systems within a retuning region. This will unavoidably result in the temporary adjacency and possibly interleaving of systems with essentially incompatible network designs.[9] Preventing, and where necessary, mitigating CMRS/public safety interference during Phase II will require careful coordination among public safety and CMRS licensees.

Commission authorization of WATG would affect both Phase I and Phase II of the 800 MHz transition in profoundly negative ways. Given the assumptions upon which most public safety communications infrastructure and handsets have been designed – an essentially "noise-free" radio-frequency (RF) environment supporting service at relatively low signal levels (*e.g.*, -101dBm for portable handsets, -104 dBm for portables) – there is essentially no room for any additional or new interference sources in the new NPSPAC channels. Adjacent channel WATG operations, however, will introduce an additional interference source into this already-challenging environment by raising the

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[7] Southern LINC – a cellular operator like Nextel – will also swap its current assignments with 806-809/851-854 incumbents during Phase I. Accordingly, all references to Nextel in this context are intended to also refer to Southern LINC participating in its licensed area in the southeastern U.S.

[8] Nextel is seeking modification of these requirements during the Phase II transition period to account for the temporary, continued interleaving of public safety and CMRS operations. *See* Letter from Lawrence R. Krevor, Nextel Communications, to Marlene Dortch, FCC Secretary, WT Docket No. 02-55 (Sept. 28, 2004). Even with these modifications, however, the rules would still require prompt mitigation of interference to public safety communications systems.

[9] As noted above, Southern LINC will also temporarily remain in the General Category channels pending the initiation and completion of Phase II of 800 MHz band reconfiguration.

noise floor beyond the design capabilities of legacy public safety communications equipment. This will certainly be true at the completion of Phase II, when 806-809/851-854 MHz is an exclusive public safety NPSPAC allocation; it will be even more critical during the Phase II transition when even a relatively low level of WATG-generated OOBE could interfere with mission-critical or life-safety public safety communications.

Given the highly limited adjacent-band interference record in Docket 03-103, authorizing WATG in the current ATG allocation without the necessary operating and network design restrictions threatens to undercut the solution to CMRS/public safety interference that the Commission has just adopted in WT Docket No. 02-55. In identifying the proper restrictions and limitations, the Commission must at a minimum consider two interference scenarios: (1) the Phase II transition period during which both CMRS and public safety licensees will operate in the new NPSPAC channels directly adjacent to the proposed WATG allocation; and (2) the post-Phase II environment in which the Commission has created a permanent home in the 806-809/851-854 MHz channel block where traditional, high-site public safety and private wireless communications systems can operate without interference caused by adjacent or spectrally proximate incompatible CMRS networks.

1.2.2. Upper ATG Band

Nextel is the primary licensee of the 900 MHz SMR channels. As Nextel deploys its 900 MHz network, it is experiencing harmful interference from adjacent-band cellular A and B block operations. Specifically, OOBE from cellular licensees' base station transmissions at 869-894 MHz are interfering with the operation of Nextel's base station receivers at 896-901 MHz. Nextel is experiencing communications-disrupting interference at approximately 25 percent of its 900 MHz cell sites – typically those co-located or nearly co-located with cellular base stations.[10] The incidence of this interference is likely to increase since about 40 percent of Nextel's planned 900 MHz base station deployment will be co-located or near co-located with cellular base stations.[11] In Nextel's experience, eliminating this problem will require cellular A & B operators to add filtering to their base stations to assure no increase in the noise floor in the 896-901 MHz band.

Moreover, without such filtering, WATG will experience the same type of OOBE interference from cellular licensees' base station transmitters at 869-894 MHz as Nextel does. Indeed, WATG is likely to experience even greater interference from Cellular A & B base station transmitters than Nextel because WATG will not have the benefit of the

[10] *See, e.g.*, Letter from Regina M. Keeney, Counsel to Nextel Communications, Inc., to Marlene Dortch, Secretary, FCC, WT Dkt. No. 02-55 (filed, Oct. 28, 2004) (describing the increasing incidence of interference to Nextel's 900 MHz SMR operations from cellular base stations in the 869-894 MHz band).

[11] Nextel and Nextel Partners currently operate more than 20,000 sites today, and Nextel is deploying additional 900 MHz equipment every day to expand the capacity of its growing network.

two megahertz of separation from the Cellular A & B base station transmitters that 900 MHz SMR does. Absent filtering, interference from Cellular A & B base station transmissions can be expected to markedly diminish the level of broadband throughput that any given WATG operator is able to achieve.

Given Nextel's experience with adjacent cellular downlink-generated interference, WATG-equipped aircraft could themselves create interference to Nextel's 900 MHz base station receivers, particularly to sites located in the vicinity of airports where departing and arriving aircraft may transmit directly into the main lobe of 900 MHz base station receive antennae.

2. Analytical Factors: Characteristics of Prospective Wideband Air-to-Ground Service

The proponents of WATG service have provided little of the basic information about their proposed systems necessary to conduct a comprehensive adjacent-band interference analysis. Information about prospective system configurations and deployment plans are fragmented among numerous individual *ex parte* presentations that proponents have provided to Commission staff; thus, it is difficult to assemble a comprehensive picture of prospective WATG services to use in quantifying the probability of adjacent band interference. Nextel has had to make certain assumptions for this analysis concerning prospective WATG system based on the limited information in the record herein. These assumptions are detailed below. In the section after that, Nextel identifies some additional WATG system characteristics that will materially affect the probability of adjacent band interference, but remain entirely unaddressed in the record established thus far in this proceeding.

2.1. WATG System Factors Considered

2.1.1. Ground Station EIRP

WATG ground stations are assumed to transmit at 56 dBm/1.25MHz EIRP. This figure is derived as follows: 43 dBm (20W) PA output + 15dBi antenna gain – 2 dB cable loss.[12] Although not specified in the record, 2dB of cable loss is typical in current CDMA deployments.

2.1.2. Aircraft Transmitter Power and Antenna Characteristics

WATG aircraft transmitters are assumed to use a fixed omni-directional antenna with 48 dBm EIRP of transmit power. This assumption assumes 43 dBm (20W) PA output plus 6 dBi of antenna gain minus 1 dB cable loss.[13]

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[12] *See, e.g.*, Letter from Donald Brittingham, Verizon, to Marlene Dortch, Secretary, FCC, WT Dkt. 03-103, Attach. 1 at 10 (filed, Sept. 10, 2004) (assuming base station transmit power of 43 dBm and 15 dBi antenna gain.)

[13] *Id.* at 11-12 (specifying certain aspects of Verizon Airfone's System 1 design). This estimate is also drawn from Verizon's oral response to questioning during the multi-party

2.1.3. Always-On Operation

The model system assumes a CDMA2000 1xEV-DO (1X Evolution, Data Optimized) architecture. EVDO is an "always on" system; *i.e.,* the transmitters and receivers on the ground and on the aircraft are continuously operating to provide service to customers. This always-on aspect of the broadband EVDO system represents a significantly increased interference probability as compared to the limited duration, limited number, customer-initiated transmissions that the current narrowband ATG system generates today.

2.1.4. Operational Bandwidth of 1.25 MHz

This analysis also assumes EVDO operates using a 1.25 MHz bandwidth channel, in contrast to the 6 kHz channels used by ATG today. Two possible system configurations are depicted below: a single licensee and a dual licensee market structure. A modest amount of additional guard band is provided in a single license case versus a dual license case. The dual licensee case may, however, provide more OOBE protection to adjacent channel licensees as a result of the antenna polarization necessary to accommodate two licensees using broadband technology within a two megahertz wide channel, such that overall adjacent channel OOBE may even out for both licensing schemes. Out-of-band emissions are assumed to rely on a standard FCC emissions mask of 43+10log(P) with 100 kHz of resolution bandwidth per Part 22.917.[14]

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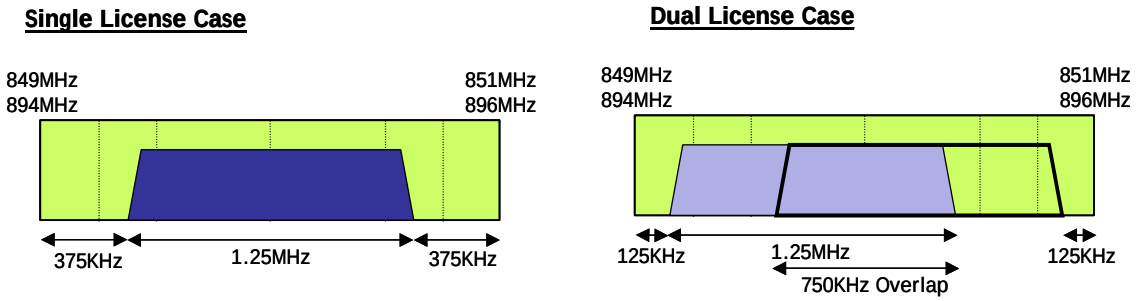
ex parte meeting with Commission staff that took place at the Commission's offices in Washington, DC on October 13, 2004. Although on other occasions Verizon Airfone has proposed to use a directional antenna on aircraft, an omni-directional antenna is assumed here. Maintaining and accurately pointing a directional antenna on board a high-speed jet while the aircraft is in motion would require the system to meet extremely costly military-level design standards that a commercially deployed system is highly unlikely to support.

[14] 47 C.F.R. § 22.917.



Cases	Out-of-Band Emissions	Remarks
Single License Case	-13dBm/100KHz or –3dBm/MHz	Both license schemes assume 43+10log(P) as the emissions mask using the same measurement techniques employed in Part 22.917
Dual License Case	-13dBm/100KHz or –3dBm/MHz	

2.1.5. Deck-to-Deck Coverage

The record in this proceeding suggests that WATG would provide "deck-to-deck" service, meaning continuous, always-on operation beginning while the airplane receives crew and passengers, during loading, taxi, takeoff, flight, landing, docking, and disembarkation. Unlike the little-used, sporadic, narrowband, high-altitude ATG that exists today, wideband ATG would be a radically different service – a scalable, always-on service in which any one operator will transmit across 1.25 MHz of bandwidth at all times.

Offering deck-to-deck operations will require airplane transmitters to operate at nearly all elevations that any given plane is capable of achieving and sustaining. For commercial aviation aircraft, the transmitters will be approximately 2-3 meters above ground elevation at airports while the plane is stationary or taxiing the runway. The transmitters are assumed to be from 3-152 meters in the immediate vicinity of airports upon takeoff and landing. Aircraft-based transmitters will then rise as they reach a commercial cruising altitude of 9,144 meters or more, depending on the type of aircraft involved and the flight path followed.

WATG advocates also propose offering service to general aviation aircraft, which operate at much lower cruising altitudes (some as low as 152 meters (500 feet)), thereby creating the potential for more pervasive impact on terrestrial operations than large, high-altitude commercial jets.

2.2. Factors Not Considered due to Insufficient Data

2.2.1. Number of Non-Airport Ground Stations

Ground stations operate as terrestrial termination points for the air-to-ground and ground-to-air traffic. One WATG system is estimated to require approximately 200 ground stations to provide commercial broadband WATG service to the public. While approximately 200 ground stations might be used for an initial deployment by one

system, this number does not necessarily represent the end state or even the most likely initial state of deployment. A dual licensee market structure could require additional base stations.[15]

Since the existing 800 MHz ATG band is only two megahertz wide in each direction, the only way for any given broadband system to add capacity is either to: (a) build more towers, or (b) use sectorized antennas. An operator will most likely need to rely on both methods to achieve the frequency reuse necessary to provide service on anything approaching widespread commercial deployment. Depending on the market and the operators' deployment choices, hundreds of additional ground stations could be necessary to meet commercial expansion needs. To the extent, however, that sectorized antennas are not feasible in the context of WATG, many more air-to-ground ground stations would likely be necessary to provide reliable broadband service to the public in flight. Without the option of using sectorized antennas, literally thousands of base stations could be required to provide a mass-market wideband ATG service. The record does not contain analysis of this scenario; therefore, Nextel cannot provide additional analysis of this prospective deployment beyond the obvious conclusion that more ground stations may pose a greater interference risk.

2.2.2. Number of Airport Ground Stations or Repeaters

WATG proponents have not described the number, configuration, and type of at-airport ground stations necessary for this service. The record does not establish how many airports WATG proponents seek to serve and whether airport service will be confined to airports in the National Plan of Integrated Airport Systems (NPIAS), commercial service airports, or some other subset of the nation's approximately 19,000 aircraft landing facilities.[16]

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[15] This statement *should not* be read to imply that Nextel favors a single licensee market structure for WATG. On the contrary, the intra-system interference mitigation protections that two WATG operators would need to deploy in order to operate within the ATG band without causing each other interference would have the salutary effect of diminishing harmful out-of-band-emissions – including those that create harmful interference to adjacent-band operators, such as public safety, SMR, and cellular licensees. Equally important, competition from multiple operators in the same band will result in lower prices, more choices and higher quality for consumers, thereby advancing the public interest.

[16] There are more than 3,300 federally funded airports within the United States' NPIAS. The NPIAS is comprised of all commercial service airports, all reliever airports, and certain selected general aviation airports. Communities that do not receive scheduled commercial service may be included in the NPIAS as sites for general aviation airports if they account for enough activity and are at least 20 miles from the nearest NPIAS airport. The 2,558 general aviation airports in the NPIAS tend to be distributed on a one-per-county basis in rural areas and are often located near the county seat. These airports, with an average of 32 based aircraft, account for 38 percent of the nation's general aviation fleets. *See generally* National Plan of Integrated Airport Systems (NPIAS) (2005-2009),

There are 546 commercial service airports in the United States.[17] The Department of Transportation defines commercial service airports as public airports receiving scheduled passenger service and having 2,500 or more enplaned passengers per year. Of these, 422 have more than 10,000 enplanements per year and are classified as primary airports.[18] It remains unclear whether proponents intend to provide service to all of these facilities or some subset of them. For example, do proponents intend to offer service only to the 31 large hub primary airports, extend service to the 37 medium-hub primary airports, or cover the nation's 74 small-hub and 280 non-hub primary airports?[19] The record in this proceeding contains virtually no information concerning the number, configuration, and type of airport base station infrastructure necessary to support WATG deck-to-deck service. It also remains unclear how many airports will have at-airport ground stations or repeaters that pose the greatest risk of interference to terrestrially based adjacent-band public safety and SMR operators. Without knowing this information, precise adjacent channel interference probabilities cannot be calculated.[20]

To the extent that WATG providers offer a deck-to-deck service, ground-focused infrastructure will be required at each aircraft landing facility; *i.e.*, there must be sufficient power flux density to provide terrestrial coverage for airplanes on the ground as well as during landing and take off. WATG providers will need to rely on downward tilting antennas, terrestrial repeaters, or other alternative infrastructure to establish links with low flying, landing, or resting aircraft. More terrestrially focused WATG infrastructure operating in the ATG bands further increases the likelihood of potential interference to adjacent channel terrestrial mobile communications systems. A precise quantification is not possible, however, given the absence of definitive airfield deployment data in the record herein. Accordingly, because the record is deficient concerning how WATG proponents would offer aircraft WATG coverage at low altitudes and on the ground, particularly during takeoff, landing and taxiing, this paper assumes WATG will employ a standard cellular antenna configuration around airports to support deck-to-deck coverage.

Report of the Secretary of Transportation to the United States Congress Pursuant to Section 47103 of Title 49, United States Code, available at: <http://www.faa.gov/arp/planning/npias/>.

[17] *Id.*

[18] *Id.*

[19] *Id.*

[20] Additionally, as noted above, the *ex parte* presentations in this docket indicate that prospective WATG providers intend to offer service to general aviation aircraft. Deck-to-deck general aviation WATG service will further expand the risk of adjacent band interference.

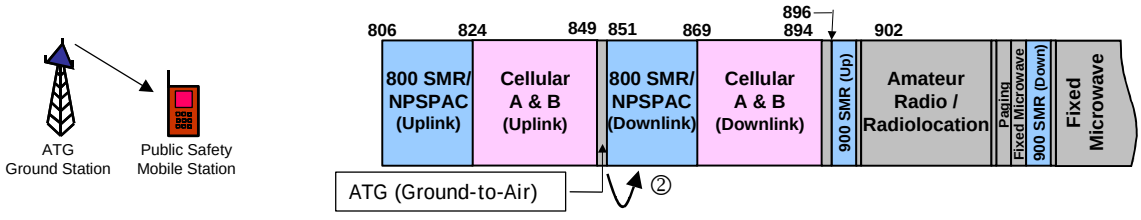
2.2.3. Number of Airborne Transmitters

There are more than 215,000 civilian aircraft in the United States.[21] Today, only about 1700 aircraft are equipped with ATG service. The *ex parte* presentations in this proceeding suggest that to be economically feasible, a future WATG service would have to be deployed on a substantially larger number of aircraft than are equipped with ATG today. Even a limited WATG penetration into the 215,000 total civilian aircraft in the United States would represent a major increase over the number of ATG airborne installations that exist today. More aircraft installations mean additional interference risk to adjacent-band operations. Again, however, the record contains insufficient information to fully evaluate this variable. Therefore, the scale, scope, and frequency of interference from airborne transmitters into the operations of terrestrial adjacent-band incumbent licensees cannot be reliably determined.

3. Interference Cases

3.1. Interference Case 1: ATG Ground Station to Public Safety Mobile Terminals and SMR Handsets

As discussed above, the prospective WATG ground-to-air (base transmit) frequencies would be immediately adjacent to the new NPSPAC channel allocation. This analysis concludes that WATG deployment offering deck-to-deck, broadband, always-on voice and data service to commercial aircraft exclusively over the current ATG allocation channels will increase the noise floor above that anticipated by the Commission in the 800 MHz reconfiguration proceeding in WT Docket No. 02-55. Expanding the WATG service to lower-flying general aviation aircraft and numerous airports will exacerbate the risk of such interference. A WATG deployment will be particularly problematic at and near airports, where highly developed multi-modal transportation networks routinely require public safety officials to confront emergency situations that depend on reliable communications.



WATG transmissions can also create intermodulation interference ("IM") on the new NPSPAC channels. WATG transmissions could combine with Nextel's operations – particularly during the Phase II transition period – creating IM products on public safety channels thereby resulting in unacceptable interference. Operating WATG with a 1.25

[21] *See* Aircraft Owners and Pilots Ass'n, *General Aviation Overview* (2004), *available at* <http://www.aopa.org/special/newsroom/facts.html>

MHz broadband technology, moreover, would make eliminating IM interference extremely difficult since the broadband channel architecture prevents retuning away from individual channels that produce IM products and would already occupy most of the available bandwidth. Under such circumstances, the only remedy for this type of interference is to reduce the output power of the WATG base stations – potentially creating large holes in desired WATG coverage.

As demonstrated in the chart below, WATG operations will cause a substantial noise floor increase in the new NPSPAC channel block, thereby jeopardizing public safety communications. This analysis assumes a standard adjacent-channel interference level of –13 dBm/100 kHz or –3 dBm/MHz. The ATG ground station is anticipated to use a net antenna gain of 13 dBi, resulting in effective OOBE of 10 dBm/MHz EIRP.

Adjacent Channel Interference Level (dBm/MHz)	ATG Ground Station Antenna Gain (dBi)	Distance Separation (Meter)	Free Space Path Loss (dB)	Public Safety Mobile Antenna Gain (dBi)	Resulting Interference Level (dBm/MHz)	PS Signal Level to Protect (dBm/MHz)	Rise over Protected PS Signal Level
-3	13	50	65	0	-55	-108	53 dB
		100	71		-61		47 dB
		500	85		-75		33 dB

This analysis demonstrates that wideband ATG will introduce a new interference source into the new NPSPAC channel Block that was not contemplated under the Commission's *800 MHz Report and Order*. Any WATG licensees that might eventually be permitted in this band should be obligated to mitigate any additional incremental OOBE to the pre-existing levels before the deployment of WATG.

At a minimum, WATG ground stations should be required to protect public safety operations in the new NPSPAC channels consistent with the interference protection standards adopted in the *800 MHz Report & Order*. WATG, like other CMRS operations in the 800 MHz band, must be required to maintain 20 dB of C/(N+I) interference protection to public safety users at a public safety desired signal strength of –101 dBm/25KHz for portables and –104 dBm/25KHz for mobiles. Therefore, overall interference contribution of WATG to the 806-809/851-854 MHz channel block cannot exceed –121 dBm or –124 dBm per 25 kHz.[22] The ATG *Report and Order* must adopt rules similar to the *800 MHz Report and Order* to include ATG operators as a part of the mix of licensees that can cause and resolve interference to public safety and must ensure that WATG shares equitable responsibility for mitigating any interference issues.

Due to the limited time available and the complexity of the *800 MHz Report and Order* rules involved, this study does not address how best to accommodate the new WATG service as an additional source of interference or how to allocate responsibility for interference mitigation among WATG and the other interfering operators consistent with

[22] Since 20 dB of C/(N+I) will be maintained as it goes through the antenna, public safety handset antenna gain is not a part of this calculation.

the licensee's responsibilities and degree of incumbency. To permit WATG to conduct operations as currently proposed, however, the Commission would need to give careful consideration to how rule changes would affect *all* of the parties involved in the 800 MHz proceeding, including public safety, cellular, SMR, fixed service, and other licensees.

3.1.1. 800 MHz Band Transition Considerations

As discussed above, the 800 MHz band reconfiguration requirements leave little or no margin for additional interference causers, particularly during Phase II of the transition period. During the transition, Nextel and NPSPAC channels will be interleaved and public safety operators may experience interference.

If WATG is deployed during Phase II, however, an even greater potential for IM interference will exist. In the 800 MHz proceeding, the Commission developed an extensive record identifying all possible sources of interference to public safety licensees and then adopted a comprehensive re-banding solution to ensure that public safety receives interference-free spectrum. Introducing a new interference source into the band will introduce a new complication into an already complicated interference-mitigation strategy.

To prevent harmful interference, particularly during the 800 MHz transition, WATG operators must provide sufficient isolation to protect public safety operations from harmful OOBE interference. Absent a more comprehensive showing that WATG will not, in fact, raise the noise floor for adjacent band operations and create other interference problems, including IM, the Commission has a number of options to mitigate interference above the lower ATG band during the 800 MHz transition:

1. The Commission could prohibit WATG from commencing operation in a given NPSPAC region until Phase II 800 MHz reconfiguration is completed in that NPSPAC region. This region-by-region approach would permit some limited form of WATG deployment, but would lessen the potential harmful interference from WATG operations during Phase I and Phase II of the transition process, which represent the times when licensees will be most susceptible to interference. The Communications Act charges the Commission with "promot[ing] safety of life and property through the use of wire and radio communication."[23] Moreover, public safety systems understandably expect to be able to communicate with robust and highly reliable systems. Limiting WATG deployment to only those NPSPAC regions that have completed the sensitive Phase II band reconfiguration process would limit interference to public safety when public safety operations are most susceptible to interference.

2. The Commission could authorize WATG, but prohibit WATG licensees from offering a deck-to-deck service, at least until all regional Phase II 800 MHz

[23] 47 U.S.C. § 151.

reconfigurations are completed. This option would permit high-altitude operations with high-elevation, skyward pointing base stations, but would prohibit takeoff, landing, taxiway, and other "deck-to-deck" service until the high-risk Phase II of the realignment plan is complete. The engineering analysis contained herein strongly suggests that lower-elevation coverage remains one of the most problematic aspects of the WATG proposals. Therefore, eliminating low- or ground-altitude service as an option, at least until the sensitive Phase II transition is completed, would go a long way to preventing the type of harmful interference that internal engineering models predict will occur. This option could allow some form of WATG deployment without compromising the objectives of the *800 MHz Report and Order*.

3. The Commission could adopt more stringent OOBE protections during Phase II of the 800 MHz transition. These limits would provide that WATG must attenuate its OOBE well below the noise floor of the new NPSPAC channel block during the transition. While it remains unclear what level of OOBE protection would be required to protect public safety during the high-risk transition period, the goal of any such limit must be to ensure that Phase II operations experience no impact from the commencement of WATG operations.

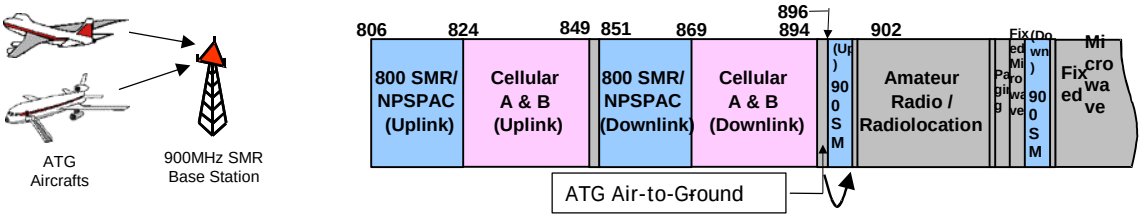
4. The Commission could conduct further proceedings on this issue with broad input from the licensees affected by the transition that may experience interference from the proposed WATG service. With so much of the record relying on loosely drafted *ex parte* presentations, the deliberative process would benefit from a record on adjacent-band interference issues. The further notice could discuss with greater specificity the proposals actually under consideration by the Commission. This notice would then allow the public safety community, handset vendors, private wireless licensees, Verizon, AirCell, Boeing, Nextel, and other concerned parties to participate in a proceeding and attempt to reach an agreement on the requisite OOBE limits needed during and after Phase II.

   This further notice could seek comment on how to authorize WATG without compromising the carefully crafted *800 MHz Report and Order*. At a minimum, the Commission would need to ensure that WATG ground stations are made responsible for protecting public safety, critical-infrastructure, SMR, and other systems from both OOBE and IM interference contributions beyond the levels expected today.

Depending on the record developed on adjacent band interference issues, WATG licensees may need to provide additional protection to victim licensees beyond the options specified above. Alternatively, WATG licensees might use one or more of the options listed above as a basis to assure sufficient protection against adjacent-band interference to potential victim licensees in the lower 800 MHz band. At this stage, however, too little information is known to endorse any one approach as offering sufficient protection against harmful interference in the lower 800 MHz band.

4. Interference Case 2: WATG Aircraft into 900 MHz SMR Base Stations

A WATG aircraft transmitter will emit into 900 MHz SMR base stations. As explained above, these base stations are already under severe strain from out-of-band-emissions from Cellular A & B downlink transmissions two megahertz below the 900 MHz SMR



band edge. Although the 894-896 MHz band is allocated for "air-to-ground" transmission, the name is something of a misnomer in the context of "deck-to-deck" operations. The WATG-equipped aircraft can be on the ground, at cruising altitude or anywhere in between. Furthermore, with a transmit power of 48 dBm EIRP for aircraft-equipped WATG transmitter, the airborne facility operates more like a flying base station than a mobile handset.[24] Finally, the 894-896 MHz band from which these transmissions will originate is immediately adjacent to the 900 MHz SMR band in which Nextel is the primary licensee.

As demonstrated in the chart below, WATG-equipped aircraft have the potential to cause harmful interference, depending on the geometry of the WATG equipped aircraft with the 900 MHz SMR base station. While a WATG-equipped aircraft is operating at cruising altitude, major adjacent-channel interference is unlikely because of the signal attenuation provided by distance separations (free space loss) of several kilometers between the aircraft and the SMR base station receive antenna. Substantial interference to 900 MHz SMR base stations could occur during take off and landing, however, because the aircraft transmitter will be line-of-site with the main lobe of the SMR base station receive antenna; *e.g.*, at WATG operations below 152 meters (500 feet). In addition, as Verizon Airfone has observed, the horizontal distance between aircraft and base stations is "small" at and near airports.[25] While difficult to quantify based on the WATG proposals currently before the Commission, reduced distance separation between aircraft and base stations will increase the potential for interference.

For purposes of this analysis, the adjacent channel interference level is assumed to be –13 dBm/100 kHz, or –3 dBm/MHz. A WATG airborne transmitter net gain of 5 dBi is also assumed. Therefore, the effective OOBE level would become (-3d dBm/MHz + 5 dBi) = +2 dBm/MHz EIRP. Standard free space path losses valued in dB are assumed. Once the WATG emissions are combined with the 900 MHz SMR base station net antenna gain

[24] *See* discussion, *supra*, § 2.1.2.

[25] Letter from Donald Brittingham, Verizon, to Marlene Dortch, Secretary, FCC, WT Dkt. No. 03-103, Attach. 1 at 3 (filed, Nov. 3, 2004) ("the horizontal distance between the aircraft and the base station tends to be small" near airports).

of 13 dBi, the resulting interference level is -76 dBm/MHz at one kilometer away and –90 dBm/MHz if the interfering WATG transmitter is located 5 kilometers away.

Adjacent Channel Interference Level (dBm/MHz)	ATG Airborne Transmitter net Gain (dBi)	Distance Separation (Km)	Free Space Path Loss (dB)	900MHz SMR Base Station Antenna Gain (dBi)	Resulting Interference Level (dBm/MHz)	Receiver Noise Floor (dBm/MHz)	Rise over Receiver Noise Floor (w/ 3dB degradation)
-3	5	1	91	13	-76	-110 (4dB of NF is assumed)	34 dB
		2	97		-82		28 dB
		5	105		-90		20 dB

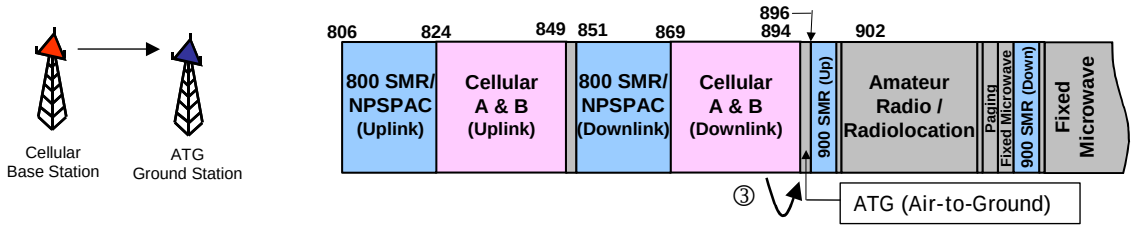
SMR base stations at 900 MHz are assumed to have 15 dBi of antenna gain with 2 dB cable loss. Based on the thermal noise of –174 dBm/Hz at room temperature, the receiver noise floor with 4 dB of Noise Figure becomes (-174 dBm/Hz + 10log(10^6Hz) + 4 dB NF) = -110 dBm/MHz (or –126 dBm/25 kHz). Therefore, if the interference level at the antenna is -123 dBm/MHz, the receiver will experience (-123 dBm/MHz + 13 dBi net antenna gain) = -110 dBm/MHz. Since the receiver noise floor is assumed to be -110dBm/MHz as well, the combined receiver noise and external interference level becomes –117 dBm/MHz, causing 3 dB degradation in receiver performance. Therefore, the required rejection between an ATG-equipped aircraft and 900 MHz SMR base station becomes (2 dBm/MHz effective OOBE + 123 dBm/MHz) = 125 dB, assuming 43+10log(P) in 100 KHz resolution bandwidth as the emissions mask for ATG.

The above analysis assumes WATG OOBE from a single WATG aircraft. Nextel's 900 MHz SMR base stations will require further protection as the number of visible aircraft increases. For example, assume 10 airplanes simultaneously landing, taking off or taxiing at an airport each spectrally "visible" to a nearby 900 MHz SMR base station. If each plane generates -123 dBm/MHz of interference, the aggregate interference to the SMR base station *increases by 10 dB.* This analysis indicates that more rigorous OOBE emissions restrictions on aircraft WATG transmitters will be required in environments where adjacent-channel systems could be exposed to multiple, simultaneous OOBE. At a minimum, the incidence of multiple aircraft being visible simultaneously to a single SMR base station requires additional evaluation.

5. Interference Case 3: Cellular Base Station into ATG Ground Station

As discussed above, this paper does not assess the impact of prospective WATG operations on adjacent cellular A and B Band operations, nor does it attempt to quantify the impact of adjacent band services on WATG. We note, however, that cellular A and B band downlink base station transmissions are causing substantial interference to Nextel's 900 MHz base station receivers and that cellular base station filtering is necessary to correct that problem. Given that the proposed WATG air-to-ground (uplink) would be immediately adjacent to the cellular A and B Band downlink frequencies, cellular base stations' OOBE will fall into the 894-896 MHz band. Given Nextel's experience with cellular OOBE in the 900 MHz SMR band 2 MHz above the Cellular A & B Downlink band (discussed above), these cellular emissions appear likely to degrade the ability of

ATG providers to offer the high capacity throughput that broadband service requires. A brief analysis follows.



The current OOBE limit for cellular licensees is contained in Section 22.917(a) of the Commission's rules, which states that "[t]he power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB."[26]

For purposes of this analysis, the adjacent channel interference level is again assumed to be –13 dBm/100kHz, or –3 dBm/MHz. The cellular base station net antenna gain is assumed to be 13 dBi. Standard free space path losses valued in dB are assumed depending on three separation distances at 20 meters (virtual collocation), 500 meters, and 1000 meters. Free space loss naturally increases with distance separation. Factoring in the WATG ground station net antenna gain, which is assumed to be 13 dBi, the resulting interference levels are –34 dBm/MHz at 20 meters, -62 dBm/MHz at 500 meters, and –68 dBm/MHz at 1000 meters. Assuming a receiver noise floor of –110 dBm/MHz, the rise over receiver noise floor with 3 dB degradation will be 76 dB at 20 meters, 48 dB at 500 meters, and 42 dB at 1000 meters.

Adjacent Channel Interference Level (dBm/MHz)	Cellular Base Station Antenna Gain (dBi)	Distance Separation (Meter)	Free Space Path Loss (dB)	ATG Ground Station Antenna Gain (dBi)	Resulting Interference Level (dBm/MHz)	Receiver Noise Floor (dBm/MHz)	Rise over Receiver Noise Floor (w/ 3dB degradation)
-3	13	20	57	13	-34	-110 (4dB of NF is assumed)	76 dB
		500	85		-62		48 dB
		1000	91		-68		42 dB

Such a high noise rise on ATG ground station receivers will substantially reduce the achievable data rate and will sometimes cause communication blockage for aircraft that are far away from ATG ground station. While the precise level of degradation is not possible to calculate based on the limited information that WATG proponents have provided in the record, the degradation – in light of the proximity and power of emissions from Cellular A & B base station transmitters to WATG ground station receivers – appears to be quite substantial.

[26] 47 C.F.R. § 22.917(a).

To accommodate for the rise over receiver noise floor, there would need to be 133 dB of isolation between Cellular A & B base station transmitters and ATG ground station receivers. This level of isolation could be achieved in any number of ways, but would offer a reasonable level of protection to the receiver noise floor with 3 dB degradation.

6. Mitigation Strategies for Anticipated Harmful Interference

Inter-band interference for proposed broadband ATG service is well documented, likely, and – more than one year into the proceeding – completely unaddressed by the proponents of WATG. If WATG is adopted without thorough consideration of the adjacent-band interference effects the service will impose on other licensees and vice versa, public safety mobile terminals will be vulnerable to interference from WATG, particularly during the sensitive transition period adopted in the *800 MHz Report and Order*. WATG-equipped aircraft will cause unacceptable interference to 900 MHz SMR band base stations, which already are suffering harmful interference from cellular base stations located 2 MHz away. In addition, long-standing OOBE interference from cellular base stations threatens to undercut the very purpose of WATG reform by dramatically decreasing anticipated throughput of the broadband services WATG is intended to provide. Finally, although not addressed in the preceding analysis, WATG ground stations, which would be adjacent to the cellular band, would also cause substantial interference to cellular base stations unless additional protections are adopted.

The foregoing analysis relies on incomplete information from WATG system proponents. While additional research and analysis is required, WATG proponents might mitigate interference in several ways. Base-to-base interference could be mitigated through combinations of various techniques including additional filtering, distance separation, antenna polarization, and antenna coordination in order to provide sufficient isolation. Whatever the precise method or combination of methods used, proponents of WATG should submit proposals indicating how to mitigate the interference issues identified here.

7. Conclusion

Detailed analysis of the precise effects of the harmful interference is difficult because virtually no record evidence exists upon which to base a conclusion on whether and how wideband ATG could offer sufficient protection adjacent public safety, SMR and cellular operators from harmful interference. At a minimum, before the Commission authorizes a new WATG service in the midst of a complex and interference-prone band segment, the Commission should permit sufficient time for study of the proponents' detailed proposals and interference-mitigation strategies.

/s/ Michael Ha

Michael Youngil Ha
Principal Technology Strategist
Nextel Communications
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